Chapter 2
Liquid Fuels

World liquids consumption in the IEO2010 Reference case increases from 86.1 million barrels per day in 2007 to 110.6 million barrels per day in 2035. Unconventional liquids, at 12.9 million barrels per day, make up 12 percent of total liquids production in 2035.

Overview

Consumption of liquid fuels and other petroleum[11] increases from 86.1 million barrels per day in 2007 to 110.6 million barrels per day in 2035 in the *IEO2010* Reference case. Although world liquids consumption actually declined in 2008 (to 85.8 million barrels per day) and again in 2009 (to an estimated 84.1 million barrels per day) as the global economic recession deepened, it is expected to recover in 2010 and beyond as economic growth resumes. In the long term, world liquids consumption increases despite world oil prices that remain above $90 per barrel (in real 2008 dollars) after 2014 and rise to more than $130 per barrel by 2035. More than 80 percent of the increase in total liquids consumption is projected for the nations of non-OECD Asia and the Middle East, where EIA expects strong economic growth (Figure 27). The transportation sector accounts for the largest increment in total liquids demand, making up nearly 80 percent of the world increase.

To satisfy the increase in world liquids demand in the Reference case, liquids production increases by 26 million barrels per day from 2007 to 2035, including the production of both conventional liquid supplies (crude oil and lease condensate, natural gas plant liquids, and refinery gain) and unconventional supplies (biofuels, oil sands, extra-heavy oil, coal-to-liquids, gas-to-liquids, and shale oil) (Figure 28 and Table 3). In the Reference case, sustained high world oil prices allow for the economical development of unconventional resources and the use of enhanced oil recovery technologies to increase production of conventional resources. High world oil prices also incentivize the development of additional conventional resources through technically difficult, high-risk, and very expensive projects, including wells in ultra-deep water and the Arctic.

The most significant non-OPEC contributors to production growth are Russia, the United States, Brazil, and Canada. Total non-OPEC liquids production in 2035 is nearly 13 million barrels per day higher than in 2007, representing 51 percent of the total world increase (Figure 29). OPEC producers[12] are assumed to restrict investment in incremental production capacity in the Reference case, below the levels justified by high prices.

Figure 27. World liquids consumption by region and country group, 2007 and 2035 (million barrels per day)

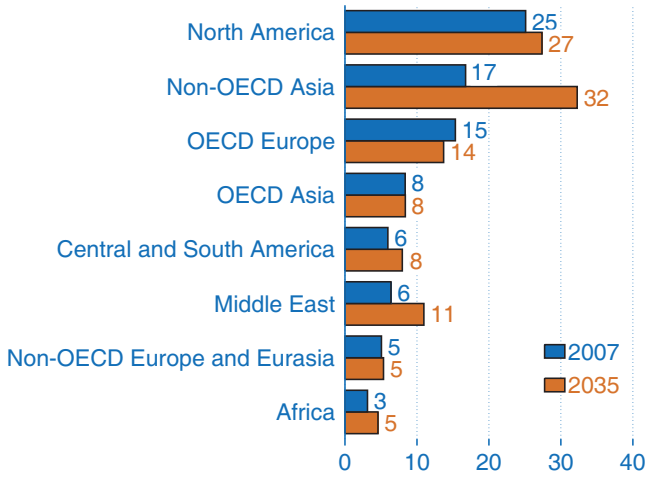
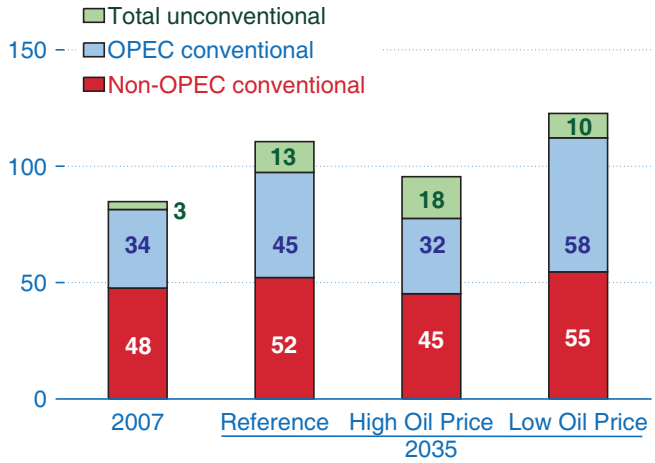


Figure 28. World liquid fuels production in three cases, 2007 and 2035 (million barrels per day)



[11] Liquid fuels and other petroleum include petroleum-derived fuels and non-petroleum-derived liquid fuels, such as ethanol and biodiesel, coal-to-liquids, and gas-to-liquids. Petroleum coke, which is a solid, is included. Also included are natural gas liquids, crude oil consumed as a fuel, and liquid hydrogen.

[12] Indonesia officially suspended its membership in OPEC on January 1, 2009. In this chapter, all references to OPEC exclude Indonesia. In addition, all time series have been updated to reflect country groupings as of January 1, 2009, so that Indonesia's liquids production is excluded from the OPEC totals for 1980 through 2035.

Table 3. World liquid fuels production in the Reference case, 2007-2035 (million barrels per day)

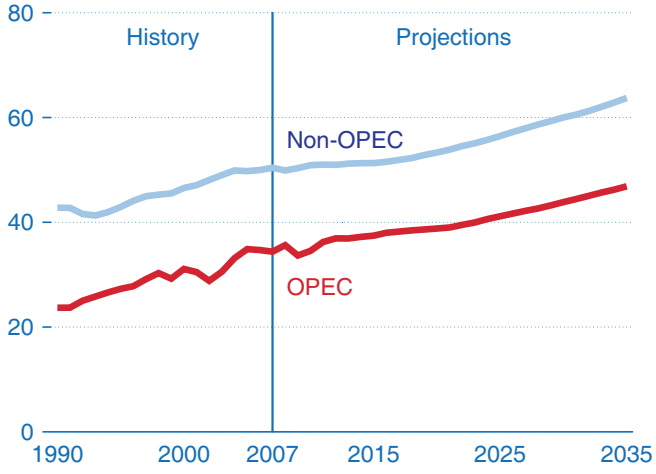
Source	2007	2015	2020	2025	2030	2035	Average annual percent change, 2007-2035
OPEC							
Conventional liquids[a]	33.8	36.4	37.5	39.7	42.3	45.3	1.0
Extra-heavy oil	0.6	0.8	1.1	1.2	1.3	1.4	3.1
Bitumen	0.0	0.0	0.0	0.0	0.0	0.0	—
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	—
Gas-to-liquids	0.0	0.2	0.2	0.3	0.3	0.3	15.4
Shale oil	0.0	0.0	0.0	0.0	0.0	0.0	—
Biofuels	0.0	0.0	0.0	0.0	0.0	0.0	—
OPEC total	**34.4**	**37.4**	**38.8**	**41.2**	**43.9**	**47.0**	**1.1**
Non-OPEC							
Conventional liquids[a]	47.7	46.2	47.0	48.8	50.8	52.5	0.3
Extra-heavy oil	0.0	0.0	0.0	0.1	0.1	0.1	—
Bitumen	1.4	2.4	2.9	3.5	4.2	5.2	4.8
Coal-to-liquids	0.2	0.3	0.5	0.8	1.1	1.4	7.9
Gas-to-liquids	0.0	0.1	0.1	0.1	0.1	0.1	—
Shale oil	0.0	0.0	0.0	0.1	0.2	0.4	15.6
Biofuels	1.2	2.4	2.8	3.2	3.5	4.1	4.6
Non-OPEC total[b]	**50.4**	**51.3**	**53.3**	**56.5**	**60.0**	**63.6**	**0.8**
World							
Conventional liquids[a]	81.4	82.6	84.5	88.5	93.1	97.7	0.7
Extra-heavy oil	0.6	0.8	1.1	1.2	1.4	1.5	3.3
Bitumen	1.4	2.4	2.9	3.5	4.2	5.2	4.8
Coal-to-liquids	0.2	0.3	0.5	0.8	1.1	1.4	7.9
Gas-to-liquids	0.1	0.3	0.3	0.3	0.4	0.4	7.3
Shale oil	0.0	0.0	0.0	0.1	0.2	0.4	15.6
Biofuels	1.2	2.4	2.8	3.2	3.5	4.1	4.6
World total	**84.8**	**88.7**	**92.1**	**97.6**	**103.9**	**110.6**	**1.0**

[a]Includes conventional crude oil and lease condensate, natural gas plant liquids (NGPL), and refinery gain.
[b]Includes some U.S. petroleum product stock withdrawals, domestic sources of blending components, other hydrocarbons, and ethers.

As a result, OPEC provides roughly 40 percent of the world's total liquids supply over the 2007-2035 period.

Unconventional resources from both OPEC and non-OPEC sources become increasingly competitive in the *IEO2010* Reference case. Production of unconventional petroleum liquids, such as Canada's oil sands and Venezuela's extra-heavy oil, is limited somewhat by environmental concerns and investment restrictions. Production of nonpetroleum unconventional liquids, such as biofuels, coal-to-liquids, and gas-to-liquids (GTL), is spurred by sustained high prices in the Reference and High Oil Price cases (Figure 30); however, their development also depends on country-specific programs or mandates. World production of unconventional liquids, which in 2007 totaled only 3.4 million barrels per day, increases in the Reference case to 12.9 million barrels per day in 2035, when it accounts for 12 percent of total world liquids production.

Figure 29. World total liquids production, 1990-2035 (million barrels per day)



World liquids consumption

World liquids consumption in the *IEO2010* Reference case increases from 86.1 million barrels per day (174 quadrillion Btu) in 2007 to 110.6 million barrels per day (223 quadrillion Btu) in 2035. World GDP is a key driver, growing by 3.4 percent per year from 2007 to 2020 and 3.1 percent per year from 2020 to 2035. Developing non-OECD nations, particularly in Asia, the Middle East, and Central and South America, are expected to have strong economic growth accompanied by increasing demand for liquids in the transportation and industrial sectors.

Rising prices for liquids increase the cost-competitiveness of non-liquid fuels, leading many users of liquids outside the transportation sector to switch to substitute sources of energy. As a result, the transportation share of total liquid fuels consumption increases, accounting for 77 percent of the overall increase in liquids consumed over the projection period across all sectors (Figure 31). In 2035, the transportation sector consumes 61 percent of total liquids supplied.

Strong expansion of liquids use is projected for non-OECD countries, fueled by a return to robust economic growth, burgeoning industrial activity, and rapidly expanding transportation use. The largest increase in regional non-OECD consumption between 2007 and 2035 is projected for non-OECD Asia, at 15.5 million barrels per day. Within non-OECD Asia, the largest increases in demand come from China (9.4 million barrels per day) and India (1.8 million barrels per day), with the increase from China being the largest for any single country worldwide. Large consumption increases are also expected in the Middle East (4.6 million barrels per day), and Central and South America (2.0 million barrels per day) (see Figure 27).

Liquids consumption in OECD regions generally grows more slowly over the next 25 years, reflecting slowly growing or declining populations and relatively slow economic growth as compared with non-OECD nations. In addition, growth in demand for liquids in many OECD countries is slowed by government policies and legislation aimed at improving the efficiency of personal motor vehicles. This includes increased automobile efficiency standards and government incentives introduced in many nations during the recession, such as the U.S. "cash for clunkers" program, designed to encourage consumers to trade in older, less efficient cars for newer ones that are more fuel-efficient. In Japan and OECD Europe, liquids consumption declines by average annual rates of 0.7 percent (0.9 million barrels per day) and 0.4 percent (1.6 million barrels per day), respectively, from 2007 to 2035.

The different growth trends for the non-OECD and OECD regions mean that, by 2025, non-OECD regions consume more liquids than OECD regions. Despite significant country-level consumption growth, China still consumes less liquid fuel than the United States in 2035.

World oil prices

The impacts of world oil prices on energy demand are a considerable source of uncertainty in the *IEO2010* projections. In addition to the Reference case, High Oil Price and Low Oil Price cases illustrate the range of that uncertainty, although they do not span the complete range of possible price paths. In the Reference case, the world oil price[13] increases from $59 per barrel in 2009 to $70 per barrel in 2010 and then rises to $95 per barrel in

Figure 30. World production of unconventional liquid fuels in three cases, 2007 and 2035 (million barrels per day)

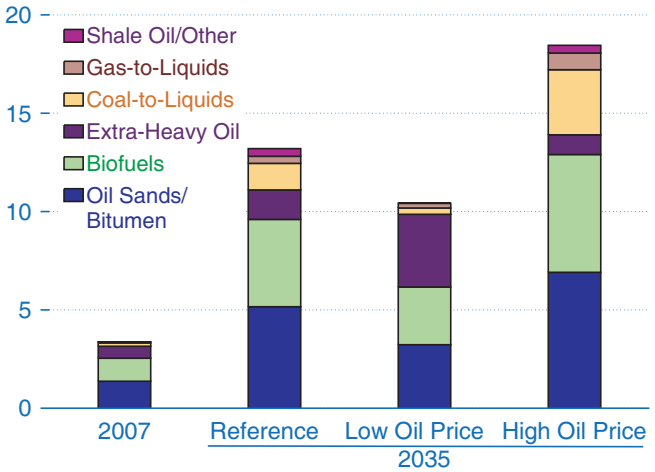
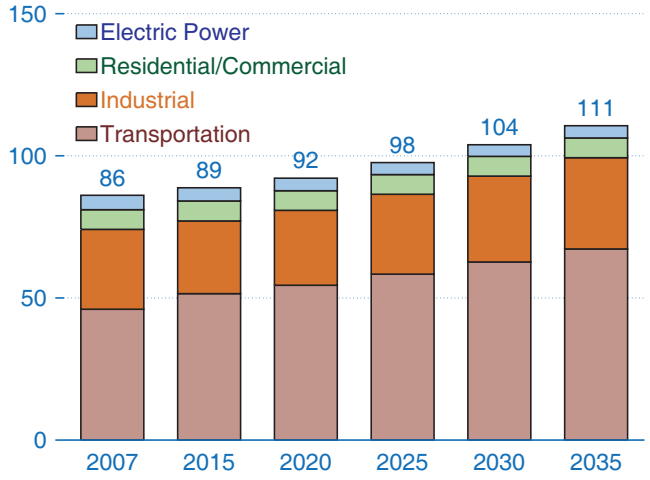


Figure 31. World liquids consumption by sector, 2007-2035 (million barrels per day)



[13] The oil price reported in *IEO2010* is for light sweet crude oil delivered to Cushing, Oklahoma. The price series is consistent with spot prices for light sweet crude oil reported on the New York Mercantile Exchange (NYMEX). All oil prices are in real 2008 dollars per barrel, unless otherwise noted.

2015 and $133 per barrel in 2035 ($224 per barrel in nominal terms) (Figure 32 and Table 4). In the High Oil Price case, the world oil price increases to $210 per barrel in 2035 ($289 per barrel in nominal terms). In the Low Oil Price case, the world oil price falls to $51 per barrel in 2035 ($72 per barrel in nominal terms). The three world oil price paths in *IEO2010* are consistent with those in EIA's *Annual Energy Outlook 2010* [**1**].

The *IEO2010* projections for total world liquids consumption in 2035 range from 90 million barrels per day in the High Oil Price case to 120 million barrels per day in the Low Oil Price case. This range indicates the substantial uncertainty in the oil market projections.

The three price cases are distinct scenarios, each reflecting alternative assumptions about the sources and costs of world oil supplies. The Reference case reflects an assumed decision by OPEC members to maintain the organization's aggregate production at approximately 40 percent of world liquids supply. To retain that share of world liquids supply, OPEC would have to increase production by 12.6 million barrels per day from 2007 to 2035, or about one-half of the projected total increase in world liquids supply. Non-OPEC conventional supplies—including production from high-cost projects and from countries with unattractive fiscal or political regimes—account for an increase of 4.8 million barrels per day over the projection, and non-OPEC production of unconventional liquid fuels supplies the remaining 8.4 million barrels per day of the increase.

The High Oil Price case assumes that several non-OPEC producers further restrict access to, or increase taxes on, production from prospective areas, and that the OPEC members reduce their production substantially below current levels. Oil prices rise above the Reference case levels, dampening demand for liquid fuels and enabling increased production from those high-cost conventional and unconventional non-OPEC oil resources that still are accessible and attractive for exploration and development.

The Low Oil Price case assumes greater access to, and more attractive fiscal regimes in, several prospective non-OPEC areas—including Russia and the Caspian region—as well as increased production from OPEC members. Under those conditions, oil prices fall below the Reference case levels, leading to increased demand for liquid fuels and dampening production of conventional and unconventional resources from non-OPEC producers that currently have attractive fiscal regimes but relatively mature or depleted resource bases.

Recent market trends

In 2009, world oil prices responded primarily to demand expectations, with producers, consumers, and traders continuing to look for any indication as to when the world's economy would recover, what shape the recovery would take, and how strong the corresponding increase in oil demand would be. Despite record levels of floating storage, gradual reductions in OPEC compliance to pledged production cuts, and even moderate reductions in factor input costs, oil prices rose throughout the year as each month brought hope that there would be some clear signal of an economic turnaround.

In addition, 2009 was an eventful year for the supply factors that drive long-term pricing. Over the course of the year, OPEC demonstrated greater dedication to supporting prices than it has historically, maintaining an average 70-percent compliance rate from February through June before falling to 60 percent later in the year [**2**]. Above-average compliance increased the group's spare capacity to 5.0 million barrels per day in December 2009. It also helped prices rise to a range of $70 to $80 per barrel, which several members of OPEC, including Saudi Arabia, Venezuela, and Algeria, have identified publicly as a desirable price level [**3**].

Figure 32. World oil prices in three cases, 1980-2035 (2008 dollars per barrel)

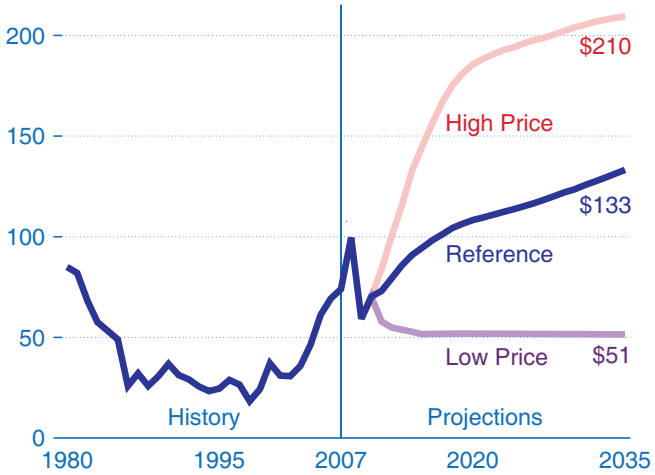


Table 4. World oil prices in four cases, 2008-2035 (2008 dollars per barrel)

	IEO2010			*IEO2009*
Year	Reference	Low Oil Price	High Oil Price	Reference case
2008	100	100	100	101
2015	95	52	145	113
2020	108	52	186	118
2025	115	52	196	125
2030	124	52	204	134
2035	133	51	210	—

Since June 2009, Iraq—the only OPEC member not currently assigned a quota—has held two bid rounds. The sum of the targeted production increase from the awarded fields is about 9.5 million barrels per day, or almost four times the country's current production. Although most industry analysts do not expect Iraq to achieve the production targets in full, especially not in the near to mid-term, the likely increase still could cause changes in OPEC's quota allocation and long-term production decisions.

The year also held significant challenges and surprises for non-OPEC supply, some with potentially long-lasting implications. Although prices rose throughout 2009, many of the supply projects delayed during the price slump that started in 2008 have not been revived. Given the time needed for project development, there is a lag between the time of investment decision and the eventual arrival of the projects in the market. Consequently, mid-term supply growth may be constrained if delayed projects are not restarted in the short term.

A related trend that began in 2008 and continued in 2009 was the decline in costs for materials, labor, and equipment ("factor inputs") necessary to develop supply projects. The decline may have encouraged delays in some projects as investors waited to secure contracts at the lowest possible cost; however, the trend appears to have bottomed out at the end of 2009 after only a slight overall reduction in costs [*4*]. Before the recent reduction in production costs, an industry research group estimated that costs had approximately doubled since 2000 [*5*]. Higher costs serve to raise the breakeven oil price at which a project would be considered economical, thus affecting decisions as to which supply projects are likely to move forward in the future.

Also starting in 2008 and continuing into 2009 was a crisis in the global credit market, which made it difficult to finance some exploration and production projects. It will take several years to realize the full effect of limits on credit availability for oil supply projects, because the projects stalled by the lack of financing, particularly exploration projects, would not have brought supply to the market for years. In addition, the recent credit crisis may also have lead to an overall and possibly lasting change in risk appetite on the part of both lenders and investors. Ironically, while credit terms were being tightened and financial risk was being trimmed, ongoing exploration efforts in Africa resulted in a wave of discoveries and new hope for unexplored and underexplored non-OPEC frontiers (see box on page 28). It remains unknown whether those exploration efforts will continue to bear fruit, and whether future efforts will be hampered by credit conditions. At present these are important uncertainties to be considered in the projections of future oil supply and demand balance.

World liquids production

In the *IEO2010* Reference case, world liquids production in 2035 exceeds the 2007 level by 26 million barrels per day. Increases in production are expected for both OPEC and non-OPEC producers. Overall, 51 percent of the total increase is expected to come from non-OPEC areas, including 33 percent from non-OPEC unconventional liquids production alone. OPEC produces 47 million barrels per day in 2035 in the Reference case, and non-OPEC producers provide 64 million barrels per day.

The Reference case assumes that OPEC producers will choose to maintain their market share of world liquids supply and will invest in incremental production capacity so that their liquids production represents approximately 40 percent of total global liquids production throughout the projection. Increasing volumes of conventional liquids (crude oil and lease condensate, natural gas plant liquids [NGPL], and refinery gain) from OPEC members contribute 10.3 million barrels per day to the total increase in world liquids production from 2007 to 2035, and conventional liquids supplied from non-OPEC nations contribute 4.8 million barrels per day.

Unconventional liquids production increases by about 5 percent annually on average over the projection period, because sustained high oil prices make unconventional liquids more competitive, and above-ground factors limit the production of economically competitive conventional liquids. Unconventional fuels account for 37 percent (9.5 million barrels per day) of the increase in total liquids production in the Reference case, and 8.4 million barrels per day of the increase in unconventional supply comes from non-OPEC sources. High oil prices, improvements in exploration and extraction technologies, emphasis on recovery efficiency, and the emergence and continued growth of unconventional resource production are the primary factors supporting the growth of non-OPEC liquids production in the *IEO2010* Reference case.

Liquids production modeling approach

The *IEO2010* projections are based on a two-stage analytical approach. Projections of liquids production before 2015 are based largely on a project-by-project assessment of production volumes and associated scheduling timelines, with consideration given to the decline rates of active projects, planned exploration and development activity, and country-specific geopolitical situations and fiscal regimes. There are often lengthy delays between the point at which supply projects are announced and when they begin producing. The extensive and detailed information available about such projects, including project scheduling and the investment

Is offshore West Africa the world's next frontier for oil?

The development of non-OPEC oil supply centers has grown and diversified widely over time. North America dominated non-OPEC supply in the early 1970s, the North Sea and Mexico evolved as major sources in the 1980s, and much of the new production in the 1990s and into the 2000s came from developing countries in Central and South America, the non-OPEC Middle East, and China. Now industry has shifted its attention to offshore resources along Africa's western coast, suggesting that Africa may become an important non-OPEC oil-producing region within a decade.

Between 2007 and 2009, oil discoveries off the West African coast resulted in a flurry of exploration and production activity, with a number of companies showing active interest in obtaining exploration blocks. In June 2007, the Jubilee field was discovered by the United Kingdom's Tullow Oil in the deep coastal waters of Ghana.[a] Initial estimates suggest that the Jubilee field contains approximately 490 million barrels of proven reserves and may have as much as 1.8 billion barrels of potential reserves.[b] Work on the Jubilee field began in 2009. Initial production is expected to begin at the end of 2010, increasing to 120,000 barrels per day in 2011.

The discovery of Jubilee spurred interest in oil exploration along the coast of several other West African nations, notably, Côte d'Ivoire, Liberia, and Sierra Leone. In September 2009, Anadarko Petroleum discovered oil off the coast of Sierra Leone at the Venus-B1 exploratory well—the first deepwater discovery in the Sierra Leone-Liberian Basin. Although its commercial viability has not yet been confirmed, the discovery serves to frame a "new oil frontier" area of the West African coast, extending from Ghana to Sierra Leone, with significant resource potential.[c]

A 2010 assessment by the U.S. Geological Survey (USGS) of two West African provinces, the Senegal Province and the Gulf of Guinea Province, estimated mean undiscovered resources of 2.4 billion barrels and 4.1 billion barrels, respectively.[d] This represents a significant increase in the undiscovered potential of the two provinces since the 2000 USGS *World Petroleum Assessment*. In 2000, the Senegal Province was estimated to hold a mere 157 million barrels of oil. The Gulf of Guinea Province estimate has grown from 1.0 billion barrels of oil resource in 2000 to 4.1 billion barrels in 2010.

While the potential resource base offshore West Africa appears to be ample, there are other important considerations that may deter the region's oil development. Investment climates vary among countries, and there are risks that must be evaluated before foreign companies commit to investing in oil production. Foreign investors attempt to limit their risks, including but not limited to political, economic, operational, and geopolitical risks.

Many West African nations have only recently recovered from civil war or other periods of political instability, and they may still be dealing with inexperienced governments, potentially suffering from corruption and mismanagement. Companies can be dissuaded from investing if they believe that business operations might be hampered by government interference. For example, the recent dispute between Kosmos Energy and the government of Ghana concerning the proposed sale of Kosmos's stake in the Jubilee field to ExxonMobil signaled potential problems for companies operating in offshore Ghana.[e] Although the dispute was resolved—at least temporarily—when Kosmos agreed to remain a partner until the field begins first production, the issue over transfer of assets could have negative impacts on future international investment.

Because this is the first time that oil production has been a consideration for many West African countries, they may have little or no legislation concerning hydrocarbon resources. Côte d'Ivoire introduced a new Oil and Gas Development Code in 1996 in an attempt to increase foreign direct investment, and the Ghanaian government is scheduled to draft legislation establishing an independent regulator to manage oil revenues before production begins at the Jubilee field

(continued on page 29)

[a]"Ghana: 'World-class' Jubilee Oilfield Larger Than Expected," *Petroleum Economist* (January 27, 2009), web site www.petroleum-economist.com (subscription site).

[b]"Africa: Jubilee Field: Ghana's Oil Industry Takes Off," iStockAnalyst.com (April 5, 2010), web site www.istockanalyst.com/article/viewiStockNews/articleid/4006121; and "Exxon's Ghana Move Raises Hopes, Tensions," *Petroleum Intelligence Weekly*, Vol. 48, No. 42 (October 19, 2009), pp. 2-3, web site www.energyintel.com/publicationhomepage.asp (subscription site).

[c]J. Collin, "Andarko: West Africa Find Opens New Frontier," *Oil Daily* (September 17, 2009), web site www.energyintel.com (subscription site).

[d]U.S. Geological Survey, World Petroleum Resources Project, "Assessment of Undiscovered Oil and Gas Resources of Four West Africa Geologic Provinces," Fact Sheet 2010–3006 (February 2010), web site http://pubs.usgs.gov/fs/2010/3006/pdf/FS10-3006.pdf.

[e]E. Gismatullin and T. Patel, "Tullow Says Kosmos to Stay in Ghana Until Production Starts" (April 22, 2010), web site www.bloomberg.com/apps/news?sid=aigcwbvWOSCE&pid=20601087.

Is offshore West Africa the world's next frontier for oil? (continued)

later this year.[f] The legislation aims to create an independent regulatory body and revenue management procedures to avoid the mismanagement and corruption that have arisen elsewhere on the continent. It remains to be seen how Sierra Leone and Liberia, both still recovering from recent civil wars, will manage this task.

The coast of West Africa represents a new frontier for the petroleum industry, but how and when the resources will be brought to market remains uncertain. Although there has been healthy exploratory activity, production from the region is still in its infancy.

[f]C. Hunter, IHS Global Insight, "Ghana: Oil & Gas: Government Policy," *Energy Country Profiles* (April 5, 2010), web site www.ihsglobalinsight.com (subscription site).

and development plans of companies and countries, make it possible to take a detailed approach to modeling mid-term supply.

Although some projects are publicized more than 7 to 10 years before their first production, others can come on line within 3 years. For that reason, project-by-project analyses are unlikely to provide a complete representation of company or country production plans and achievable production volumes beyond 3 years into the future. Instead, production decisions made after the mid-term, or 2015, are assumed to be based predominantly on resource availability and the resulting economic viability of production.

In view of the residual effects of previous government policies and the unavoidable lag time between changes in policy and any potential production changes, however, most country-level changes in production trends are noticeable only in 2020 and beyond. Geopolitical and other "above-ground" constraints[14] are not assumed to disappear entirely after 2015, however. Longstanding above-ground factors for which there are no indications of significant future changes—for instance, the government-imposed investment conditions currently in place in Iran, or OPEC adherence to production quotas—are expected to continue affecting world supplies long after 2015. Even if above-ground constraints were relaxed, the expansion of production capacity could be delayed, depending on the technical difficulty and typical development schedule of the projects likely to be developed in a particular country.

For some resource-rich countries it is assumed that current political barriers to production increases will not continue after 2015. For instance, both Mexico and Venezuela currently have laws that restrict foreign ownership of hydrocarbon resources. Their resource policies have discouraged investment—both foreign and domestic—and hindered their ability to increase or even maintain historical production levels. In the Reference case, both Mexico and Venezuela ease restrictions at some point after 2015, allowing some additional foreign involvement in their oil sectors that facilitates increases in liquids production, including from deepwater prospects in Mexico and extra-heavy oils in Venezuela's Orinoco belt.

Iraq is another resource-rich country where currently there are significant impediments to investment in the upstream hydrocarbon sector. Liquids production in Iraq dropped substantially after the U.S.-led invasion in 2003. From 2002 to 2003 production declined from 2.0 million barrels per day to 1.3 million barrels per day, and since then it has achieved only inconsistent and slow growth. Although Iraq's production levels are not expected to increase substantially in the near term, it is assumed that political and legal uncertainty subsides, and that renewed investment and development activity ensue, resulting in significant growth in production from 2015 to 2035.

Non-OPEC production

The return to sustained high oil prices projected in the *IEO2010* Reference case encourages producers in non-OPEC nations to continue investment in conventional liquids production capacity and increase investment in enhanced oil recovery (EOR) projects and unconventional liquids production. Non-OPEC production increases steadily in the projection, from 50 million barrels per day in 2007 to 64 million barrels per day in 2035, as high prices attract investment in areas previously considered uneconomical, and fears of supply restrictions encourage some net consuming nations to expand unconventional liquids production from domestic resources, such as coal and crops.

Despite the maturity of most non-OPEC producing basins, conventional liquids production in the Reference case increases from 48 million barrels per day in 2007 to 52 million barrels per day in 2035. The overall increase results primarily from production increases in four

[14] "Above-ground" constraints refer to those nongeological factors that could affect supply, including but not limited to government policies that limit access to resources; conflict; terrorist activity; lack of technological advances or access to technology; price constraints on the economic development of resources; labor shortages; materials shortages; weather; environmental protection actions; and short- and long-term geopolitical considerations.

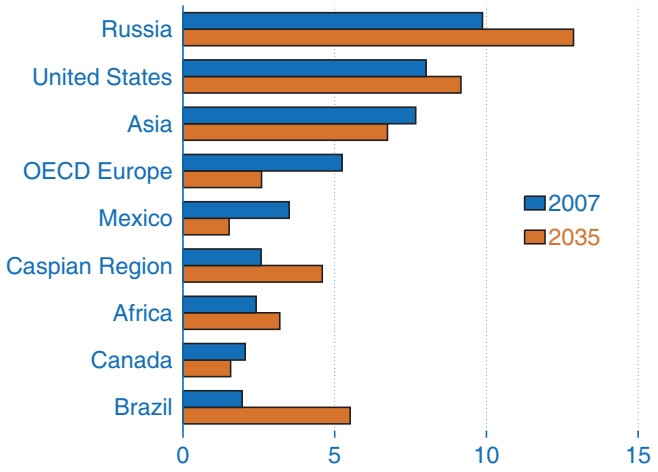
countries: Brazil, Russia, Kazakhstan, and the United States (Figure 33). Among non-OPEC producers, the near absence of prospects for new, large conventional petroleum liquids projects, along with declines in production from existing conventional fields, results in heavy investment in the development of smaller fields. Producers are expected to concentrate their efforts on more efficient exploitation of fields already in production, either through the use of more advanced technology for primary recovery efforts or through EOR. Those efforts are expected to allow most established non-OPEC producers to maintain or slow production declines but not to raise production volumes.

In the Reference case, unconventional liquids production from non-OPEC suppliers rises to 6 million barrels per day in 2020 and 11 million barrels per day in 2035. In the High Oil Price case, non-OPEC unconventional liquids production rises to 17 million barrels per day in 2035, as significantly higher prices encourage the development of alternative fuel sources to the limits imposed by expected environmental protection measures and industry expansion in general. In contrast, in the Low Oil Price case, fewer unconventional resources become economically competitive, and non-OPEC production of unconventional liquids rises to only 7 million barrels per day in 2035.

Major areas of decline in non-OPEC liquids production

In the *IEO2010* Reference case, Mexico and the North Sea are the only non-OPEC production areas that lose more than 1 million barrels of liquids production per day from 2007 to 2035. The most significant decline in non-OPEC liquids production is for OECD Europe, with a decrease from 5.4 million barrels per day in 2007 to 2.9 million barrels per day in 2035. Most of that decline is in North Sea production, which includes offshore operations by Norway, the United Kingdom, the Netherlands, and Germany. Over time, fewer and fewer prospects capable of compensating for declines in existing fields have been discovered. The drop in North Sea liquids production does not vary significantly in the High and Low Oil Price cases, both because it is based on depletion of resources and because all the countries currently producing liquids from North Sea operations are expected to continue encouraging investment and providing open access to development.

Figure 33. Non-OPEC conventional liquids production by region, 2007 and 2035 (million barrels per day)



In Mexico, liquids production sinks to approximately 1.4 million barrels per day in 2025 before slowly rebounding to 1.6 million barrels per day in 2035, still 1.9 million barrels per day below 2007 volumes. The rebound after 2025 depends entirely on the development of potential resources in the deepwater Gulf of Mexico, which must begin some years in advance of any increase in production levels. The outlook for Mexico's liquids production is markedly different from the *IEO* projection just 3 years ago, in which production did not fall below 2.9 million barrels per day and a long-term recovery began in 2013. The difference between the projections is a result of declines at Cantarell that were more severe than expected, along with diminished expectations for Chicontepec production and more pessimistic assumptions about the level of future investment, both foreign and domestic, in Mexico's deepwater production.

Although the shortage of investment in Mexico is expected to lead to a mid-term decline, Mexico has potential resources to support a long-term recovery in total production, primarily in the Gulf of Mexico. The extent and timing of a recovery will depend in part on the level of economic access granted to foreign investors and operators. Mexico's national oil company, PEMEX, currently does not have the technical capability or financial means to develop potential deepwater projects in the Gulf of Mexico.

Major areas of growth in non-OPEC liquids production

The largest increase in non-OPEC total liquids production is expected for Brazil, with projected growth of 4.9 million barrels per day by 2035 from its 2007 level of 2.3 million barrels per day. Of that increase, 3.6 million barrels per day is attributed to conventional liquids production. The strong growth in Brazil's conventional production results in part from short- and mid-term increases at producing fields for which expansions are either planned or in progress. It also results in part from recent and expected discoveries in the Campos and Santos basins, including the massive Tupi and related Guara and Iara discoveries, which both add to production in the mid- and long term and suggest the presence of other large fields in the same formation [**6**]. The vast size of the sub-salt potential in Brazil, as well as national

economic strategy and industrialization goals, have led Brazil to pursue new petroleum legislation [7]. The legislative change most pertinent to production potential is the requirement that the state oil company, Petrobras, be the sole operator and a minimum 30-percent equity holder for all sub-salt fields.

Although Petrobras has repeatedly proven itself a leader in deepwater development and is known to have the technical capabilities to develop sub-salt prospects, it is not expected to have the resources (financial, labor, etc.) to develop its domestic plays completely on its own. The different *IEO2010* price cases assume different investment terms offered by Brazil to foreign investors and hence different rates of sub-salt development. The High Oil Price case assumes tighter terms of access to conventional resources, resulting in average annual growth of 2.2 percent and conventional production that reaches 3.5 million barrels per day in 2035. In comparison, the Low Oil Price case assumes open terms of access to conventional resources, resulting in average annual growth of 4.6 percent and conventional production of 6.6 million barrels per day in 2035.

In addition to the growth in conventional liquids production, Brazil's ethanol production also increases, from 0.3 million barrels per day in 2007 to 1.6 million barrels per day in 2035 in the Reference case. This growth is a result of steady increases in yields and the expansion of crop production. Brazil's major ethanol production is derived from sugar cane, currently the highest-yielding and cheapest feedstock for ethanol. Brazil also has a large amount of land available for sugar cane production in the form of previously cleared, underutilized pasture land. The country's domestic consumption is not expected to rise as fast as its expansion of ethanol production, making Brazil a net ethanol exporter over the course of the projection. Thus, its production depends largely on other countries' policies and demand for ethanol.

In the High Oil Price case, Brazil's ethanol production totals 2.0 million barrels per day in 2035, reflecting higher demand for ethanol both at home and abroad. In the Low Oil Price case, which assumes reduced domestic and international demand for ethanol, Brazil's ethanol production totals 1.2 million barrels per day in 2035. Even in the Low Oil Price case, however, there is only a small drop in Brazil's domestic ethanol consumption, because of the country's mandatory minimum E25 blend and the fact that ethanol makes up a nearly 50-percent share of the country's domestic gasoline market [8].

The second-largest contributor to future increases in non-OPEC total liquids production is the United States. U.S. conventional liquids production grows from 8.0 million barrels per day in 2007 to 9.2 million barrels per day in 2035 in the Reference case, as rising world oil prices spur both onshore and offshore drilling. In the short term, the vast majority of the increase in crude oil production comes from deepwater offshore fields. Fields that started producing in 2009, or that are expected to start producing in the next few years, include Great White, Norman, Tahiti, Gomez, Cascade, and Chinook. All are in water depths greater than 2,600 feet, and most are in the U.S. Central Gulf of Mexico. Production from those fields, combined with increased production from fields that started producing in 2007 and 2008, contributes to the near-term growth in U.S. offshore production. Production from other recently discovered and yet-to-be discovered fields offsets production declines in older fields, resulting in a net increase in liquids production through 2035.

U.S. lower 48 onshore production of crude oil continues to grow through 2035, primarily as a result of increased application of EOR techniques. In 2035, EOR accounts for 37 percent of total onshore production. The rate of growth in domestic crude oil production depends largely on assumptions about world oil prices and improvements in technology, because remaining onshore resources typically require more costly secondary or tertiary recovery techniques. In a future world where carbon dioxide emissions may be captured for sequestration, increased carbon dioxide supply could spur additional EOR activities.

U.S. unconventional liquids production becomes more significant as world oil prices rise, with domestic production of biofuels increasing from 0.46 million barrels per day in 2007 to 1.6 million barrels per day in 2035 in the Reference case. Although advances in coal liquefaction technology have made it commercially available in other countries, including South Africa, China, and Germany, the technical and financial risks of building what would be essentially a first-of-a-kind facility in the United States have discouraged significant investment thus far. In addition, the possibility of new legislation aimed at reducing U.S. greenhouse gas emissions creates further uncertainty for future investment in CTL. With ongoing improvement in oil shale technology, commercial production starts in 2023 and increases rapidly to 1.7 percent of total U.S. liquids supply in 2035. However, oil shale development suffers from environmental, technical, and financial uncertainties similar to those for CTL.

Canada's production of conventional liquids declines slowly in the Reference case, by a total of just under 0.5 million barrels per day from 2007 to 2035. However, increased production of unconventional petroleum liquids from oil sands more than offsets the decline in conventional production. As a result, Canada's total liquids production doubles in the projection, from 3.4 million

barrels per day in 2007 to 6.8 million barrels per day in 2035.

Russia and Kazakhstan are the other key players in non-OPEC production growth. However, non-OECD Europe and Eurasia is a region prone to territorial disputes, transportation blockages, contractual changes, and political intervention. For example, Russia's production is expected to decline in the mid-term, with recent trends indicating that tax policies which previously caused companies to operate at a net financial loss may soon be reinstated, creating a large disincentive for potential private investment in resource development [***9***].

After declining to 9.4 million barrels per day in 2016, Russia's liquids production begins a slow increase to 9.8 million barrels per day in 2020 in the Reference case, as uncertainty about tax regimes lessens. In addition, the annual increases in the world oil price assumed in the *IEO2010* Reference case spur liquids development and allow Russia's production to reach 12.8 million barrels per day in 2035. Although exploration in eastern Siberia is expected during the projection period, Arctic exploration is not. In the High and Low Oil Price cases, which assume different levels of economic access granted to investors in the long term, Russia's total liquids production in 2035 ranges from 8.6 to 15.7 million barrels per day, respectively.

Mid-term growth in Kazakhstan's production depends predominantly on the resources of the Kashagan and Tengiz oil fields, as well as the ability of investors to transport production from those projects to the world market. Although known and potential resources are sufficient to support the growth of liquids production in Kazakhstan, they could be undermined by a lack of easy export routes. Currently, exports are limited to six routes: the CPC pipeline, Atyrau-Samara pipeline, and railway shipments can transport a total of 0.8 million barrels per day to Russia; another pipeline can move 0.2 million barrels per day to China, and two barge routes allow shipments of about 0.1 million barrels per day to Azerbaijan and Iran.

Kazakhstan's export potential is strongly affected by its geographical position. Attaining the production levels projected in the Reference case depends not only on resource availability and production but also on the construction of export routes—a task requiring regional cooperation that has not been easy to achieve in the past. A number of possible projects to expand Kazakhstan's capacity for liquids exports have been proposed over the past several years. The most likely expansions in the near term are capacity increases in the pipelines to Russia and China [***10***].

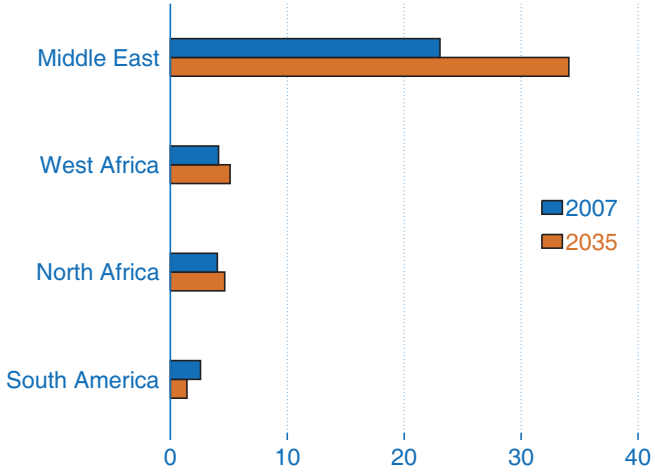
In addition to the problem of transportation capacity, Kazakhstan has previously reopened legal contracts with private foreign investors, forcing renegotiation of investment returns and making companies reluctant to increase their investment in the country's energy sector. Because of the varying degrees of resource access and investment terms, Kazakhstan's total liquids production in 2035 ranges from 2.2 million barrels per day in the High Oil Price case to 3.7 million barrels per day in the Low Oil Price case.

OPEC production

Total liquids production from OPEC nations increases from the 2007 level of 34.4 million barrels per day at an average annual rate of 1.0 percent, resulting in the production of 47.0 million barrels of liquids per day in 2035, of which 34.3 million barrels per day originates in the Middle East (Figure 34). OPEC decisions on investment in additional production capacity are the primary difference between the three price cases in *IEO2010*. The Low Oil Price case assumes that OPEC members will increase investment either through their own national oil companies or by allowing greater economic access to foreign investors, depending on the country. It also assumes that OPEC members will expand production capacity in an attempt to maximize government revenue through increased production. OPEC production in the Low Oil Price case increases by 27.1 million barrels per day from 2007 to 2035, to 61.5 million barrels per day or approximately 50 percent of total world liquids production in 2035.

In the High Oil Price case, OPEC member countries maintain record high prices by restricting production targets to a smaller share of world total liquids production each year. As a result, OPEC production accounts for less than 35 percent of the world total in 2035. Volumetric reductions are concentrated in the mid-term,

Figure 34. OPEC conventional liquids production by region, 2007 and 2035 (million barrels per day)



with liquids production falling by 2.4 million barrels per day from 2007 to 2015 and gaining 1.0 million barrels per day from 2015 to 2035.

Throughout the projection period, Saudi Arabia remains the largest liquids producer in OPEC, with total production increasing from 10.3 million barrels per day in 2007 to 15.1 million barrels per day in 2035, as prices stabilize at historically high levels and world consumption continues to grow. Thirty percent of the increase (1.4 million barrels per day) is expected to be NGPL production related to expansion of natural gas production. The total production increase equates to an average annual growth rate of 1.4 percent, based on the assumption that Saudi Arabia will continue with its current plan to maintain spare production capacity at levels between 1.5 and 2.0 million barrels per day.

Iraq increases its liquids production by 3.9 percent per year in the *IEO2010* Reference case, the largest annual average growth in total liquids production among all OPEC members. The projection assumes that political, legislative, logistical, investment, and security uncertainties in Iraq will be resolved in the long term, and that OPEC constraints and resource availability will be the factors with the strongest influence on Iraq's willingness and ability to increase production (see box on page 34).

In addition to political and legislative uncertainty, import and export infrastructure are also expected to limit production growth in Iraq to 0.5 million barrels per day from 2007 to 2015. If the country is able to achieve long-term political and economic stability and expand the capacity of import and export routes as projected in the Reference case, investment in production capacity could rise by an average of 5.2 percent annually from 2015 and 2030 before slowing to a more modest 3.8 percent per year from 2030 to 2035. The fact that Iraq has the resources necessary to support such growth in the long run, yet produced only 2.1 million barrels per day in 2007, illustrates the significant impacts that the political environment and other above-ground constraints can have on production projections.

Qatar has the second-highest average annual growth rate in total liquids production among OPEC nations from 2007 to 2035 in the Reference case, at 3.3 percent, with total volumes increasing from 1.2 million barrels per day in 2007 to 2.5 million barrels per day in 2035. About one-half of the increase consists of crude oil and lease condensate production; production of NGPLs contributes another 0.4 million barrels per day; and GTL projects add just over 0.2 million barrels per day. Despite the current negative outlook for many previously announced GTL projects around the world, the return and persistence of historically high oil prices in the Reference case supports the operation of Qatar's Pearl facility (0.1 million barrels per day capacity) and expansion of its Oryx facility (adding another 0.1 million barrels per day).

Total liquids production in Iran is expected to be restricted by political rather than resource-related factors. The political factors include the effectiveness of the national oil company's operations, the ability of the government and foreign investors to agree on contractual terms, and continuing financial sanctions. In the *IEO-2010* Reference case, Iran's oil production declines from 2007 through 2035 because of both financial and political constraints on the development of new oil and natural gas prospects. In addition, the projections anticipate that natural gas demand for domestic electric power and heat production will limit the amount of natural gas available for improving oil recovery through natural gas reinjection. Political factors and investment constraints affect Iran's liquids production so severely that production in 2035 varies by 2.7 million barrels per day across the *IEO2010* projections, from 2.6 million barrels per day in the High Oil Price case to 5.3 million barrels per day in the Low Oil Price case.

In the OPEC nations of Western Africa, total liquids production increases from 4.1 million barrels per day in 2007 to 5.1 million barrels per day in 2035 in the Reference case. Angola expands production to 2.5 million barrels per day in 2020—almost entirely by increasing crude oil and condensate production from offshore projects—before entering a slow but steady resource-driven decline in the long term. Nigeria's liquids production is likely to be hampered in the short term by conflict and infrastructure difficulties; in the long term, however, a higher level of known resources enables Nigeria's liquids production to grow at an average annual rate of 0.9 percent, from 2.4 million barrels per day in 2007 to a total of 3.0 million barrels per day in 2035.

Recent history suggests that Venezuela's national government reacts to high oil prices by tightening investment terms for foreign direct investment and limiting access to its reserves. As a result, in the Reference case, with prices rising in real terms through 2035, further mandated changes in contractual terms, along with threats of actions to recapture upside returns from potential investors, are likely to hinder Venezuela's production potential in the short term and discourage investment in and development of additional projects in the long term. The trend will be particularly evident in the mature conventional oil basins, with conventional production declining by 1.1 million barrels per day over the period from 2007 levels of 2.1 million barrels per day. However, development of several extra-heavy oil projects in the Orinoco belt offsets some of the decline in conventional liquids production.

Ecuador rejoined OPEC in October 2007, after having suspended its membership in 1999. Ecuador is a

New Iraqi oil production: How much; how fast?

Iraq holds a considerable portion of the world's conventional oil reserves, but has been unable to increase oil production substantially in recent years due to conflict and geopolitical constraints. As violence in Iraq has lessened, there has been a concerted effort to increase the country's oil production, both to bolster government revenues and to support wider economic development. Recently, Iraq offered prequalified foreign oil companies two opportunities to bid on designated fields under specific terms of investment. The success of the bidding rounds and the level of interest from foreign companies have raised hopes that oil production could increase substantially over a short period of time, with some Iraqi government officials stating that the country could increase its production to 12 million barrels per day by 2017.[a] Although Iraq has the reserves to support such growth, it will need to overcome numerous challenges in order to raise production to even a fraction of that goal.

Iraq has an estimated 115 billion barrels of proven conventional oil reserves, the third largest in the world after Saudi Arabia (260 billion barrels) and Iran (138 billion barrels).[b] However, Iraqi oil production was significantly affected not only by the U.S.-led invasion in 2003 and subsequent armed conflict, but also by neglect of the oil industry infrastructure and restrictions on investment resulting from United Nations sanctions imposed during the Saddam Hussein regime before the invasion. Oil production capacity has not increased substantially since the recent abatement of hostilities, and Iraq's current total production is about 2.5 million barrels per day—still below the peak annual average of 2.9 million barrels per day in 1989.

Between June 2009 and January 2010, Iraq awarded development service contracts for 10 oil projects to foreign companies, the majority of which were consortia formed to share the responsibility, risk, and, ultimately, returns on each of the projects. Originally, the Iraqi Ministry of Oil had expected the development of the fields up for bidding to raise Iraq's production capacity to 6 million barrels per day, in line with the Ministry's strategic goal.[c] However, heavy competition and high expectations for the fields led bidding companies to propose production levels that were significantly higher than expected. As a result, rather than raising the country's total production to 6 million barrels per day, the proposed production from all awarded fields suggests that Iraq's total production could increase to 12 million barrels per day in 2017 (see table below).

(continued on page 35)

Results of Iraq bidding rounds, 2010

Field	Consortium operator	Plateau production target (million barrels per day)	Remuneration fee (dollars per barrel)	Plateau production target duration (years)	Current production (million barrels per day)	Planned production increase (million barrels per day)
First bid round						
Rumaila	BP	2.85	2.00	7	1.00	1.85
West Qurna (Phase 1)	ExxonMobil	2.33	1.90	7	0.27	2.06
Zubair	Eni	1.20	2.00	7	0.21	1.00
Second bid round						
Majnoon	Royal Dutch Shell	1.80	1.39	10	0.06	1.75
Halfaya	CNPC (PetroChina)	0.54	1.40	13	0.00	0.53
Qaiyarah	Sonangol	0.12	5.00	9	0.00	0.12
West Qurna (Phase 2)	Lukoil	1.80	1.15	13	—	1.80
Garraf	Petronas	0.23	1.49	13	—	0.23
Badra	Gazprom	0.17	5.50	7	—	0.17
Najmah	Sonangol	0.11	6.00	9	—	0.11
Total					**1.54**	**9.61**

Source: IHS Global Insight, Energy Country Profiles, "Iraq: Oil & Gas Upstream" (last updated March 31, 2010), web site www.ihsglobalinsight.com (subscription site).

[a]IHS Global Insight, "Country Summary—Iraq" (updated April 30, 2010), web site www.ihsglobalinsight.com (subscription site).
[b]"Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 107, No. 47 (December 21, 2009), pp. 20-21, web site www.ogj.com (subscription site).
[c]IHS Global Insight, "Country Summary Upstream—Iraq" (updated March 31, 2010), web site http://myinsight.ihsglobalinsight.com (subscription site).

New Iraqi oil production: How much; how fast? (continued)

EIA analysis suggests that, even in a stable political and security climate, it would be extremely difficult to raise production by nearly 10 million barrels per day over such a short period. The two recent historical examples of massive production capacity expansion are those of Russia, where production increased by 3.8 million barrels per day over a 10-year period, and Saudi Arabia, where production increased by 2.0 million barrels per day over a 5-year period. The proposed pace and scale of Iraq's planned production expansion defy historical precedents and ignore a long list of logistical and political impediments.

The *IEO2010* Reference case expects significant delays in current production plans because of limitations on Iraq's service sector; import difficulties; likely constraints on the number of operating rigs and skilled personnel available; and limitations on the export infrastructure, with current pipelines able to only support marginal increases in flows. There are also security threats from current and past conflicts, with pipelines still at risk of being attacked, field surfaces populated with unexploded ordinances, and land mines that must be cleared. Finally, there is legislative uncertainty, particularly related to the Kurdistan region. The prospects for long-term growth, however, are bright.

The uncertainty associated with the evolution of Iraq's upstream oil sector is reflected in the range of projections for liquids production in 2035. In the Reference case, the political and security situation in Iraq stabilizes, and a few of the operating companies overcome, in some measure, the obstacles they face. In this case, Iraq's total liquids production rises to 2.8 million barrels per day in 2017 and 6.1 million barrels per day in 2035. In the *IEO2010* Low Oil Price case, Iraq's total liquids production reaches 8.3 million barrels per day by 2035, reflecting greater success in addressing the considerable difficulties facing oil industry expansion. In the High Oil Price case, liquids production reaches only 4.2 million barrels per day in 2035, because companies to a great extent are unable to reduce the difficulties they face in their attempts to increase production.

relatively small oil producer in comparison with other OPEC members, producing 0.5 million barrels per day of oil in 2007. Liquids production in Ecuador declines through 2015 in the Reference case, as uncertainties associated with the country's Hydrocarbons Law make foreign companies reluctant to investment in Ecuador's oil sector [***11***]. After 2015, although investment in the country's oil sector continues to be hindered by high investment risk, development of its ITT heavy oil field in the Amazon helps to stabilize its production. Consequently, liquids production in Ecuador rebounds to just under 0.5 million barrels per day in 2025 and remains fairly flat through 2035.

Unconventional liquids production

Unconventional liquids play an increasingly important role in meeting demand for liquid fuels over the course of the *IEO2010* projections. In the Reference case, 11.6 percent of world liquids supply in 2035 comes from unconventional sources, including 1.7 million barrels per day from OPEC and 11.2 million from non-OPEC sources. Although the volume and composition of unconventional production vary between the *IEO2010* Low and High Oil Price cases (from 17.9 million barrels per day in the High Price case to 10.5 million barrels per day in the Low Price case), the geographic origin of each unconventional liquid type is relatively constant across the cases, usually being limited to countries where projects are underway or advertised.

OPEC unconventional production

OPEC's unconventional production consists predominantly of extra-heavy oil production in Venezuela (from the Orinoco belt) and GTL production in Qatar. In the Reference case, Venezuela's extra-heavy oil production rises from 0.6 million barrels per day in 2007 to 1.4 million barrels per day in 2035, and Qatar's GTL production increases from a negligible amount in 2007 to 0.2 million barrels per day in 2035. Although the resources to support production at those levels abound in the two countries, large investments will be required to bring them to market, and the timing of such investment is uncertain.

There are four major projects currently operating in Venezuela's Orinoco belt, but they have been suffering from poor maintenance and lack of investment. Venezuela's ability to increase its extra-heavy oil production will depend on the level of foreign investment and expertise it is able to attract for extraction and upgrading projects. In the Reference case, only two Orinoco belt projects are developed over the course of the projection period: the Junín 4 (operated by a consortium of Chinese companies) and Junín 6 (operated by a consortium Russian companies). The two projects add 0.4 million barrels per day of production capacity each.

In the Low Oil Price case, Venezuela improves contract terms and stabilizes its investment climate to attract more foreign investment in the development of Orinoco resources, including Junín 2 and the Carabobo area,

which contribute 0.2 and 1.2 million barrels per day, respectively. In addition, several other development projects are undertaken in the long term. In contrast, in the High Oil Price case, Venezuela restricts access to its resources and thus discourages the development of even the Junín 4 and 6 projects. The collapse of bilateral development agreements means that investment in the extra-heavy oils of the Orinoco belt is limited to Venezuela's state oil company, Petróleos de Venezuela S.A. (PDVSA), resulting in a gradual decline in production to 0.4 million barrels per day in 2035, only one-third the amount projected in the Reference case.

Non-OPEC unconventional production

Outside OPEC, unconventional liquids production comes from a much more diverse group of countries and resource types. As a whole, non-OPEC unconventional liquids production increases by 8.4 million barrels per day from 2.8 million barrels per day in 2007 to 11.2 million barrels per day in 2035, with 69 percent coming from OECD countries. By volume, the countries making the largest contribution to the increase in non-OPEC unconventional liquids are Canada (an increase of 3.8 million barrels per day**),** the United States (1.8 million barrels per day), Brazil (1.3 million barrels per day), and China (0.8 million barrels per day).

In each of the three cases, Canada's bitumen (oil sands) production makes up more than 30 percent of total non-OPEC unconventional production, ranging from 3.2 million barrels per day in the Low Oil Price case to 6.9 million barrels per day in the High Oil Price case. Bitumen production in the High Oil Price case ramps up quickly in the short to mid-term then begins to slow in the long term, following closely the assumed world oil price path in High Price case. In the Low Oil Price case, production growth stagnates because the price is too low for new projects to be economical. Over time, reductions in the cost of technology lead to an overall increase in production.

Biofuels production in the Reference case increases from 1.2 million barrels per day in 2007 to 4.0 million barrels per day in 2035, or an average annual growth rate of 4.6 percent. The largest increase in biofuels production over the projection period comes from Brazil, where production grows by 1.3 million barrels per day from 2007 to 2035. Strong growth in biofuels consumption is projected for the United States, where production of biofuels increases by 1.1 million barrels per day, from 0.5 million barrels per day in 2007 to 1.6 million barrels per day in 2035. The growth in U.S. biofuels production is supported by the Energy Independence and Security Act of 2007, which mandates increased use of biofuels.

Government policies are the main drivers of biofuels production. Biofuels are used as a means to reduce greenhouse gas emissions, promote energy security, and support local economic development. To achieve those goals, many countries set mandates for the amount of biofuels to be used and give tax credits to biofuel producers. The United States, for example, mandates 36 billion gallons of biofuels by 2022 under the Energy Independence and Security Act of 2007. The European Union mandates that biofuels must make up 10 percent of the liquid fuels market by 2020, according to the European Union Biofuels Directive [***12***]. Canadian producers receive payments or operating grants based on output, and the Chinese government has a flexible subsidy scheme with payments based on plant profitability [***13***]. The Canadian and Chinese tax credits are designed to expire over time as the cost of production falls and oil prices rise.

Despite the wide range of biofuels incentive programs, some recent studies suggest that biofuels may not be as effective in reducing greenhouse gas emissions as previously thought. As a result, many countries have relaxed or postponed renewal of their mandates. For example, Germany reduced its biofuels quota for 2009 from 6.25 percent to 5.25 percent [***14***]. The global economic recession has also dampened investment in biofuels development. In light of those developments, world biofuels production in 2030 is 40 percent lower in the *IEO2010* Reference case than was projected in the *IEO2009* Reference case.

As in the Reference case, biofuels become more competitive with conventional oil products in both the High and Low Oil Price cases; however, the level of competitiveness depends on the oil price assumption. In the Low Price case, only the cheapest and most cost-effective feedstocks and production technologies are competitive with gasoline and diesel fuels. In the High Price case more feedstocks and production processes are competitive. Total biofuel production in 2035 is 2.9 million barrels in the Low Oil Price case and 6.0 million barrels in the High Oil Price case. The growth of biofuel production slows in all cases from 2007 to 2015, as the current generation of crops reach their economic potential, then accelerates after 2016 with the advent of new technologies that use cellulosic feedstocks.

China is the primary coal-to-liquids producer in all the *IEO2010* cases, with 2035 production levels ranging from 0.2 million barrels per day (or 56 percent of the world total) in the Low Oil Price case to 2.0 million barrels per day (60 percent of the world total) in the High Oil Price case. Other major producers are the United States and South Africa, which produce about 0.2 and 0.3 million barrels per day, respectively, in the Reference case, 0.9 and 0.3 million barrels per day in the High Oil Price case, and less than 0.1 million barrels per day each in the Low Oil Price case.

The unconventional liquid product that consistently contributes the least to total unconventional production in each of the *IEO2010* cases is GTL. In the Reference and Low Oil Price cases, GTL production is limited primarily to Qatar, although South Africa and Nigeria also produce small volumes. In the High Oil Price case, the United States rapidly becomes the world's largest GTL producer, accounting for 0.5 million barrels per day of the world's total of 0.8 million barrels per day in 2035. (For a discussion of GTL prospects in the United States, see EIA's *Annual Energy Outlook 2010*, pages 39-40.)

World oil reserves

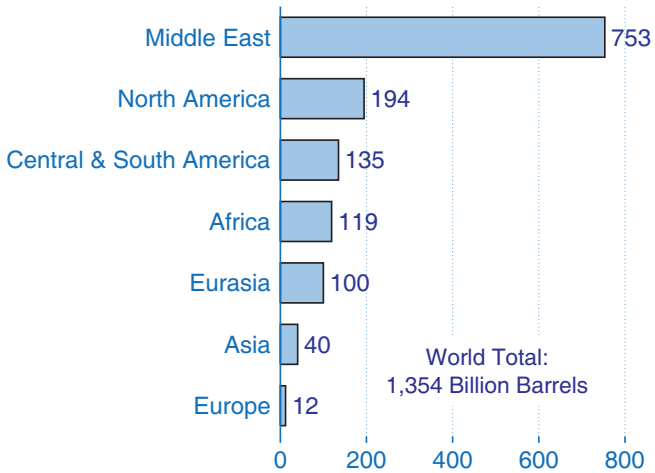
As of January 1, 2010, proved world oil reserves, as reported by the *Oil & Gas Journal*, were estimated at 1,354 billion barrels—12 billion barrels (about 1 percent) higher than the estimate for 2009 [***15***]. According to the *Oil & Gas Journal*, 56 percent of the world's proved oil reserves are located in the Middle East (Figure 35). Just under 80 percent of the world's proved reserves are concentrated in eight countries, of which only Canada (with oil sands included) and Russia are not OPEC members (Table 5).

Proved reserves of crude oil are the estimated quantities that geological and engineering data indicate can be recovered in future years from known reservoirs, assuming existing technology and current economic and operating conditions. Companies whose stocks are publicly traded on U.S. stock markets are required by the U.S. Securities and Exchange Commission (SEC) to report their holdings of domestic and international proved reserves, following specific guidelines. In December 2008, the SEC released revisions to its reserves reporting requirements in an attempt to provide investors with a more complete picture of the reserves held by reporting companies by recognizing the technologies and reserve quantification methods that have evolved over time. Country-level estimates of proved reserves from the *Oil and Gas Journal* are developed from the data reported to the SEC, from foreign government reports, and from international geologic assessments. The estimates are not always updated annually.

Whereas proved reserves include only those estimated quantities of crude oil from known reservoirs, they are only a subset of the entire potential oil resource base. Resource base estimates include estimated quantities of both discovered and undiscovered liquids that have the potential to be classified as reserves at some time in the future. The resource base may include oil that currently is not technically recoverable, but could become recoverable in the future as technologies advance.

Readers may notice that, in some cases in the *IEO2010* projections, country-level volumes for cumulative production through 2035 exceed the estimates of proved reserves. This does not imply that resources and the physical limits of production have not been considered in the development of production forecasts, or that the projections assume a rapid decline in production immediately after the end of the projection period as reserves are depleted. EIA considers resource availability in all long-term country-level projections, the aggregation of

Figure 35. World proved oil reserves by geographic region as of January 1, 2010 (billion barrels)



Source: *Oil & Gas Journal*.

Table 5. World oil reserves by country as of January 1, 2010 (billion barrels)

Country	Oil reserves	Percent of world total
Saudi Arabia	259.9	19.20
Canada	175.2	12.94
Iran	137.6	10.16
Iraq	115.0	8.50
Kuwait	101.5	7.50
Venezuela	99.4	7.34
United Arab Emirates	97.8	7.22
Russia	60.0	4.43
Libya	44.3	3.27
Nigeria	37.2	2.75
Kazakhstan	30.0	2.22
Qatar	25.4	1.88
China	20.4	1.51
United States	19.2	1.42
Brazil	12.8	0.95
Algeria	12.2	0.90
Mexico	10.4	0.77
Angola	9.5	0.70
Azerbaijan	7.0	0.52
Norway	6.7	0.49
Rest of World	72.2	5.33
World Total	**1,353.7**	**100.00**

Source: *Oil & Gas Journal*.

which gives the total world production projection. However, proved reserves are not an appropriate measure for judging total resource availability in the long run. For example, despite continued production, global reserves have not declined historically due to exploration, discovery, and reserve replacement.

In order to construct realistic and plausible projections for liquids production, and especially for petroleum liquids production, underlying analysis must both consider production beyond the intended end of the projection period and base production projections on the physical realities and limitations of production. The importance of approaching an assessment of liquids production in this way is illustrated by the recent history of U.S. reserve estimates. Whereas the United States reported 22.5 billion barrels of proved reserves in 1998, proved reserves of 19.1 billion barrels were reported in 2009—a decrease of only 3.4 billion barrels despite the cumulative 24.2 billion barrels of liquids supplied from U.S. reserves between 1998 and 2009.

Proved reserves cannot provide an accurate assessment of the physical limits on future production, but rather are intended to provide insight as to company- or country- level development plans in the very near term. In fact, because of the particularly rigid requirements for the classification of resources as proved reserves, even the cumulative production levels from individual development projects may exceed the initial estimates of proved reserves.

EIA attempts to address the lack of applicability of proved reserves estimates to long-term production projections by developing a production methodology based on the true physical limits of production, initially-in-place volumes, and technologically limited recovery factors. By basing long-term production assessments on resources rather than reserves, EIA is able to present projections that are physically achievable and can be supported beyond the 2035 projection horizon in *IEO-2010*. The realization of such production levels depends on future growth in world demand, taking into consideration such above-ground limitations on production as profitability and specific national regulations, among others.

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